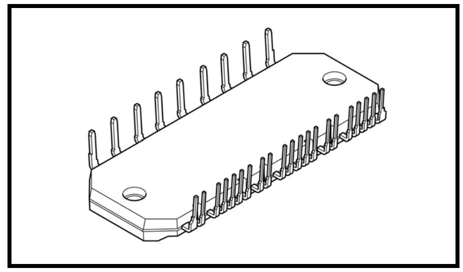
TOSHIBA Intelligent IGBT Module

MIG10J504H

Features

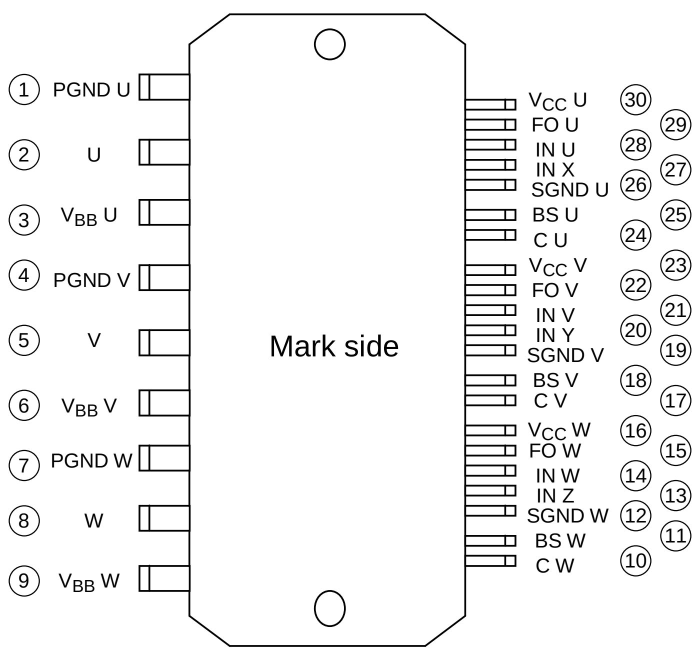


Weight: 18 g (typ.)

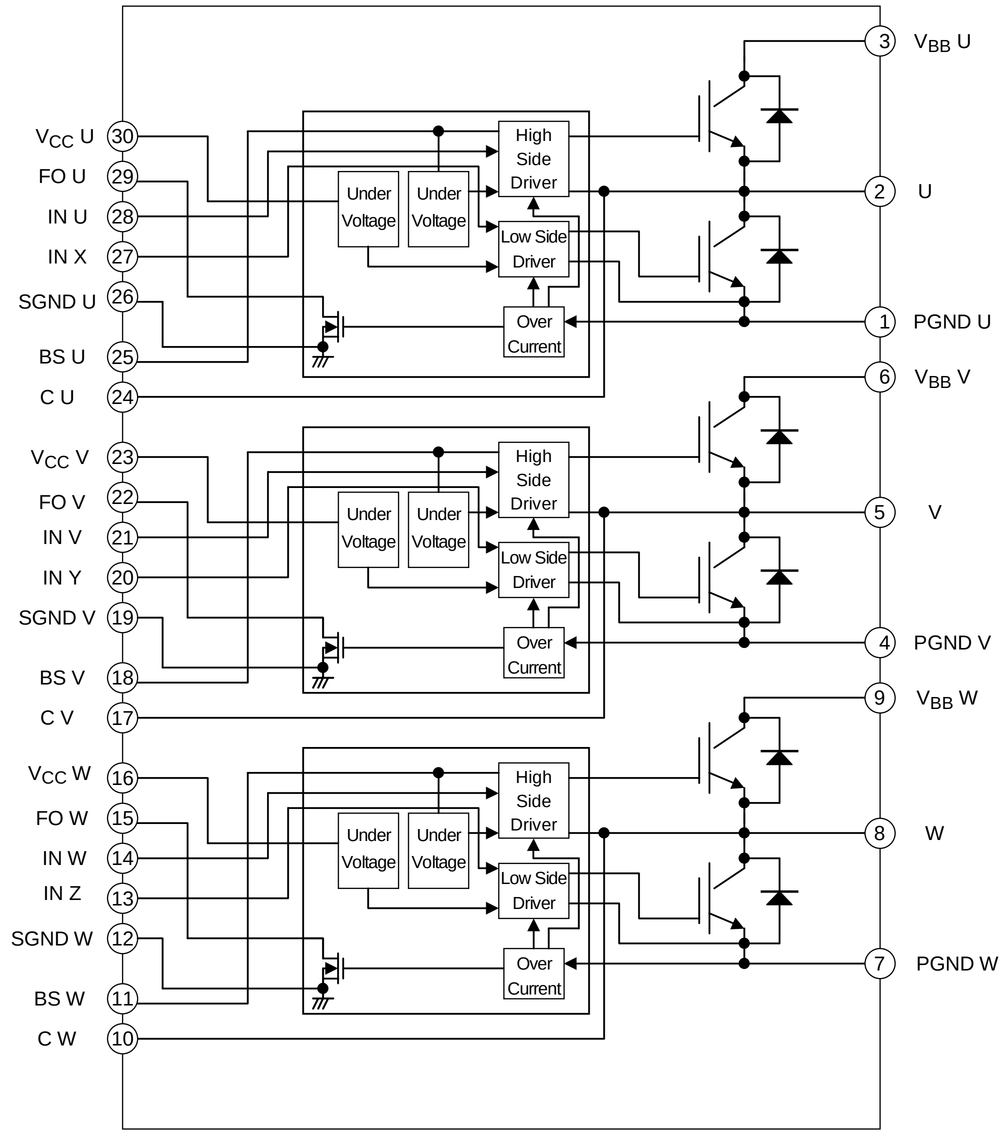
- The 4th generation trench gate thin wafer NPT IGBT is adopted.
- FRD is built in.
- I/O input: logic level (3.3 V / 5 V)
- The level shift circuit by high-voltage IC is built in.
- The simplification of a high side driver power supply is possible by the bootstrap system.
- Short circuit protection for a lower arm IGBT and the power supply under voltage protection function are built in.
- Short circuit protection state for a lower arm IGBT is outputted.
- The lower arm emitter terminal has been independent by each phase for the purpose of the current detection at the time of vector control.
- Low thermal resistance by adoption of original high thermal conduction resin.

Since this product is MOS structure, it should be careful of static electricity in the case of handling.

Pin Assignment



Block Diagram



Pin Description

Pin No.	Symbol	Pin Description
1	PGND U	U-Phase Power Ground pin (connect a current detecting resistor between this pin and SGND U pin)
2	U	U-Phase output pin
3	V_{BB} U	U-Phase high-voltage power supply pin
4	PGND V	V-Phase Power Ground pin (connect a current detecting resistor between this pin and SGND V pin)
5	V	V-Phase output pin
6	V_{BB} V	V-Phase high-voltage power supply pin
7	PGND W	W-Phase Power Ground pin (connect a current detecting resistor between this pin and SGND W pin)
8	W	W-Phase output pin
9	V_{BB} W	W-Phase high-voltage power supply pin
10	C W	W-Phase bootstrap capacitor connecting pin (−)
11	BS W	W-Phase bootstrap capacitor connecting pin (+)
12	SGND W	W-Phase Signal Ground pin
13	IN Z	W-Phase low-side input pin (negative logic)
14	IN W	W-Phase high-side input pin (negative logic)
15	FO W	W-Phase Diagnosis output pin (open drain output. Wired or connection can be performed with the diagnosis output pin of other phase.)
16	V_{CC} W	W-Phase control power supply (+15 V typ.)
17	C V	V-Phase bootstrap capacitor connecting pin (−)
18	BS V	V-Phase bootstrap capacitor connecting pin (+)
19	SGND V	V-Phase Signal Ground pin
20	IN Y	V-Phase low-side input pin (negative logic)
21	IN V	V-Phase high-side input pin (negative logic)
22	FO V	V-Phase Diagnosis output pin (open drain output. Wired or connection can be performed with the diagnosis output pin of other phase.)
23	V_{CC} V	V-Phase control power supply (+15 V typ.)
24	C U	U-Phase bootstrap capacitor connecting pin (−)
25	BS U	U-Phase bootstrap capacitor connecting pin (+)
26	SGND U	U-Phase Signal Ground pin
27	IN X	U-Phase low-side input pin (negative logic)
28	IN U	U-Phase high-side input pin (negative logic)
29	FO U	U-Phase Diagnosis output pin (open drain output. Wired or connection can be performed with the diagnosis output pin of other phase.)
30	V_{CC} U	U-Phase control power supply (+15 V typ.)

Absolute Maximum Ratings ($T_j = 25°C$)

Stage	Characteristics		Condition	Symbol	Rating	Unit
Inverter	Power supply voltage		V_{BB}-PGND Terminal	V_{BB}	450	V
				V_{BB} (surge)	500	
	Collector-emitter voltage			V_{CES}	600	V
	Collector current	DC	Tc = 25°C	I_C	10	A
		1 ms	Tc = 25°C	I_{CP}	20	
	Forward current	DC	Tc = 25°C	I_F	10	A
		1 ms	Tc = 25°C	I_{FM}	20	
	Collector power dissipation (per 1 IGBT chip)		Tc = 25°C	P_C	43	W
	Collector power dissipation (per 1 FRD chip)		Tc = 25°C	P_C	25	W
	Output voltage rate of change			dv/dt	20	kV/μs
Control	Control supply voltage		BS-C Terminal	V_{BS}	20	V
			V_{CC}-GND Terminal	V_{CC}	20	
	Input voltage		IN-GND Terminal	V_{IN}	−0.5 to 5.5	V
	Fault output supply voltage		FO-GND Terminal	V_{FO}	20	V
	Fault output current		FO sink current	I_{FO}	15	mA
	PGND-SGND voltage difference		PGND-SGND Terminal	$V_{PGND-SGND}$	−5 to 5	V
Module	Operating temperature			T_{OPE}	−20 to 100	°C
	Junction temperature (Note 1)			T_j	150	°C
	Storage temperature			T_{stg}	−40 to 125	°C
	Isolation voltage		60 Hz sinusoidal, AC 1 min	V_{ISO}	2500	Vrms
	Screw torque		M3	—	0.5	N·m

Note 1: Although a junction temperature is 150°C the own maximum moment of a power chips which it builds in this module, the average operation junction temperature for carrying out safe operation specifies it as 125°C or less.

Electrical Characteristics ($T_j = 25°C$)

1. Inverter Stage

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Collector cut-off current		I_{CEX}	V_{CE} = 600 V, V_{CC} = 15 V, V_{BS} = 15 V, V_{IN} = 5 V	—	—	1	mA
Collector-emitter saturation voltage		$V_{CE\ (sat)}$	V_{CC} = 15 V, V_{BS} = 15 V, I_C = 10 A, V_{IN} = 0 V	—	1.7	2.2	V
Forward voltage		V_F	I_F = 10 A	—	1.4	1.9	V
Switching time	Turn-on time	t_{on}	V_{BB} = 300 V, V_{CC} = 15 V, V_{BS} = 15 V, I_C = 10 A, inductive load (Note 2)	—	400	700	ns
	Rise time	t_r		—	40	80	
	Turn-on delay time	$t_{d\ (on)}$		—	360	—	
	Turn-off time	t_{off}		—	500	800	
	Fall time	t_f		—	70	300	
	Turn-off delay time	$t_{d\ (off)}$		—	430	—	
	Recerse recovery time	trr		—	75	—	

2. Control Stage

Characteristics		Symbol	Test Condition		Min	Typ.	Max	Unit
Current dissipation for 1 arm		I_{BS}	V_{CC} = 15 V, V_{BS} = 15 V	V_{IN} = 5 V	—	360	600	μA
				VIN = 0 V	—	470	1000	
		I_{CC}	V_{CC} = 15 V, V_{BS} = 15 V	V_{IN} = 5 V	—	0.9	1.5	mA
				VIN = 0 V	—	1.0	1.6	
Input voltage		$V_{IN\ (on/off)}$	V_{CC} = 15 V		1.5	2.3	2.7	V
Input current		I_{IH}	V_{CC} = 15 V, V_{IN} = 5 V		–30	–5	0	μA
		I_{IL}	V_{CC} = 15 V, V_{IN} = 0 V		–60	–30	0	
Fault output voltage		V_{FO}	I_{FO} = 5 mA		—	0.8	1.2	V
Short current protection voltage		V_{sense}	V_{CC} = 15 V (Note 3)		1.16	1.28	1.41	V
Short current protection delay time		t_{sc}	V_{CC} = 15 V		1.0	1.5	2.0	μs
Fault output pulse width		t_{Fo}	V_{CC} = 15 V		1	2	3	ms
Under voltage protection for high side arm	Trip level	$V_{BS}UVD$	—		10.0	11.0	12.0	V
	Reset level	$V_{BS}UVR$			10.5	11.5	12.5	
Under voltage protection for low side arm	Trip level	$V_{CC}UVD$	—		10.5	11.5	12.5	V
	Reset level	$V_{CC}UVR$			11.0	12.0	13.0	

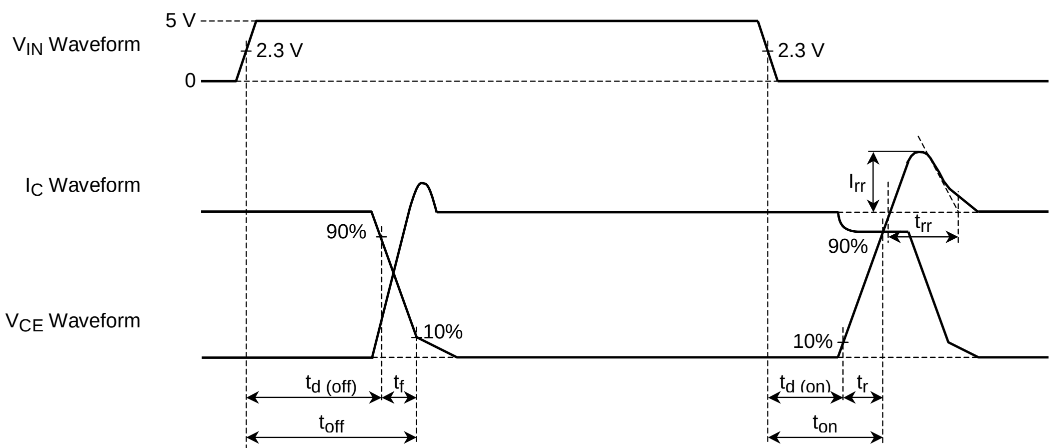
3. Thermal Resistance ($Tc = 25°C$)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Thermal resistance	$R_{th\ (j-c)}$	Transistor stage	—	—	2.9	°C/W
		Diode stage	—	—	5.0	

4. Recommended conditions for application

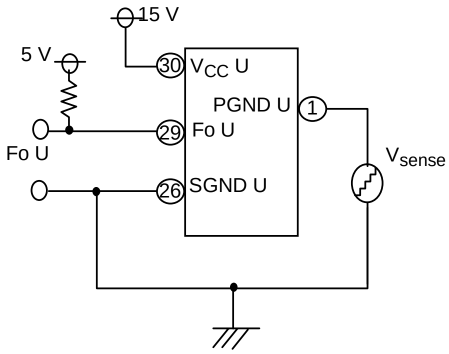
Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Operating power supply voltage	V_{BB}	—	50	300	400	V
Control supply voltage	V_{BS}	—	13.5	15	16.5	V
	V_{CC}	—	13.5	15	16.5	
Switching frequency	fc	—	—	15	—	kHz
Dead time	t_{dead}	V_{BB} = 300 V, V_{CC} = 15 V, V_{BS} = 15 V, I_C = 10 A, inductive load	1	—	—	μs
Minimum Input pulse width	$t_{win\ (min)}$	V_{CC} = 15 V, V_{BS} = 15 V	—	1	—	μs

Note 2: Switching waveform

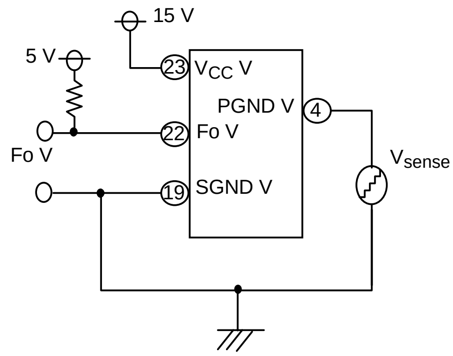


Note 3: V_{sense} measurement circuit

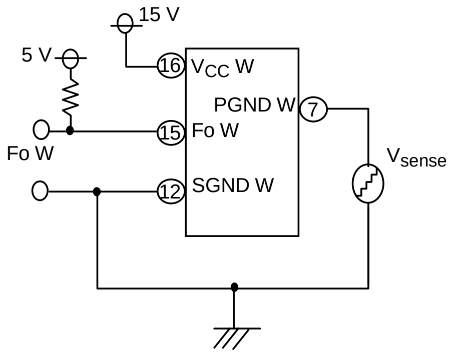
U-Phase



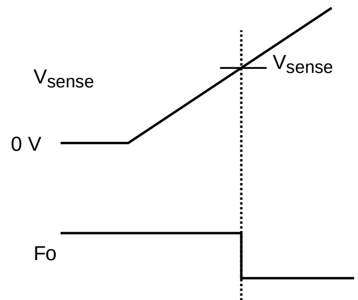
V-Phase



W-Phase



Timing Chart

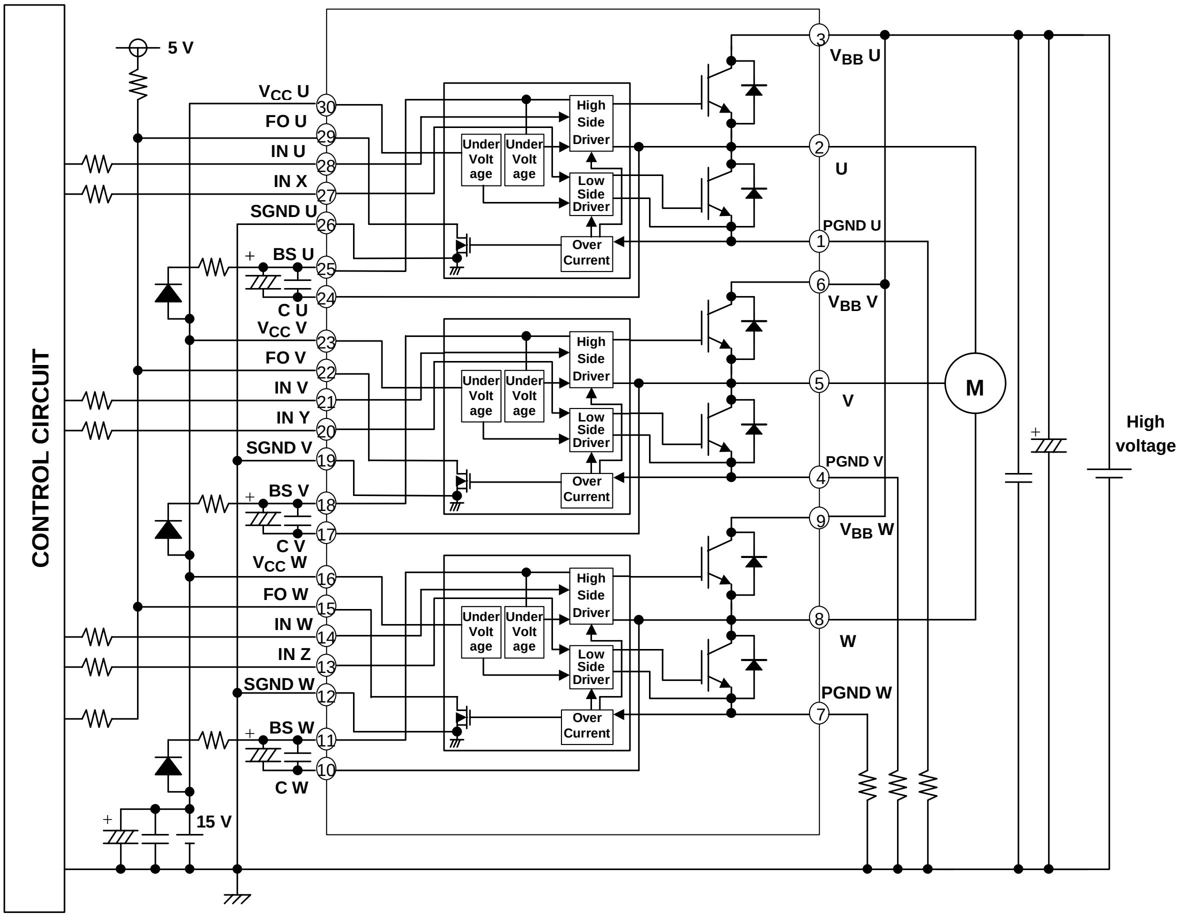


V_{sense} is measured by giving the sweep voltage from the outside like the above-mentioned.

When the overcurrent detection value is set by an actual application, it is necessary to consider the resistance of the internal bonding wire.

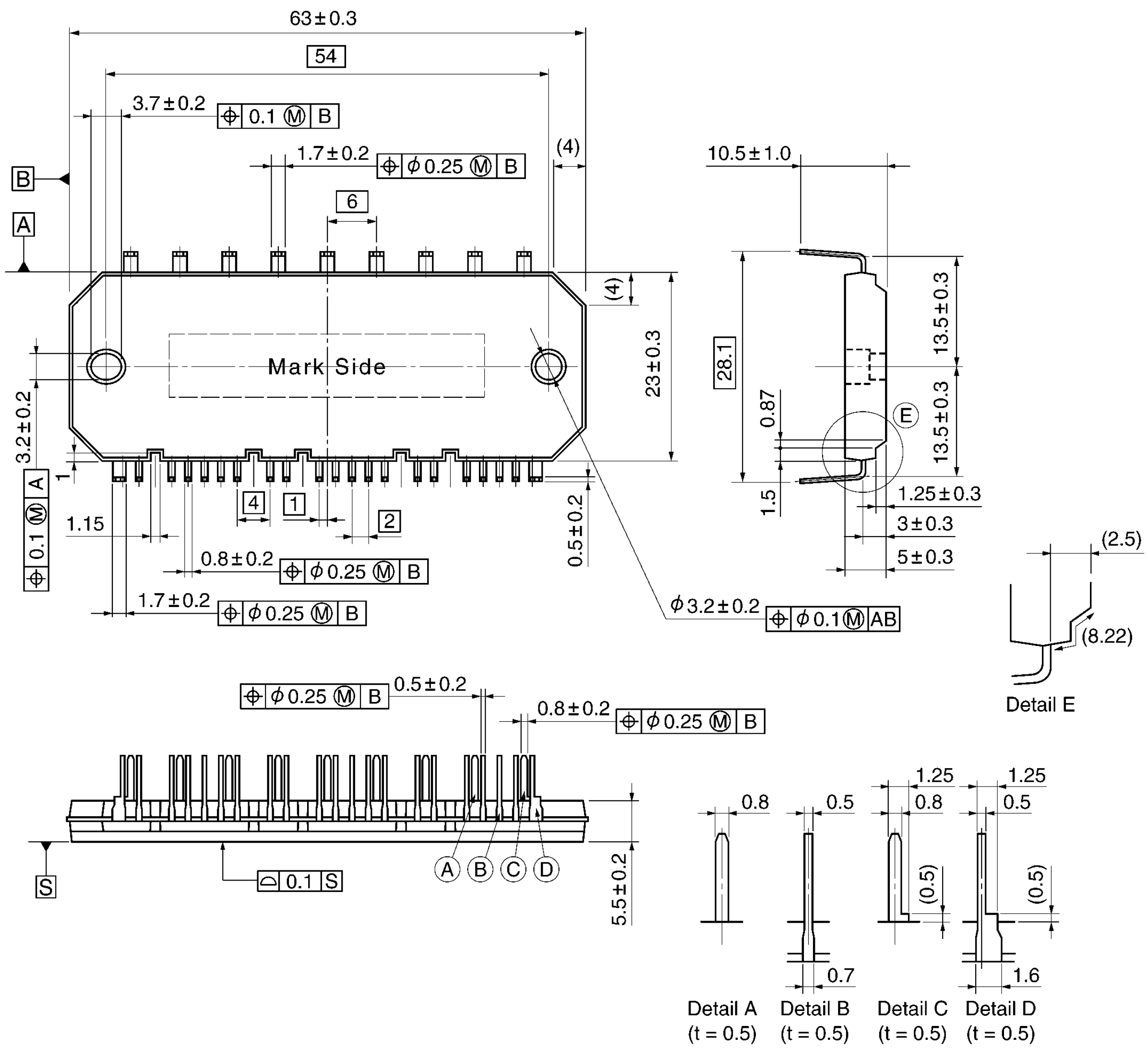
The resistance of the internal bonding wire is 11 mΩ.

The Example of an Application Circuit (in the case of not insulating with a control side)



Package Dimensions: TOSHIBA 2-63A1A

Unit: mm



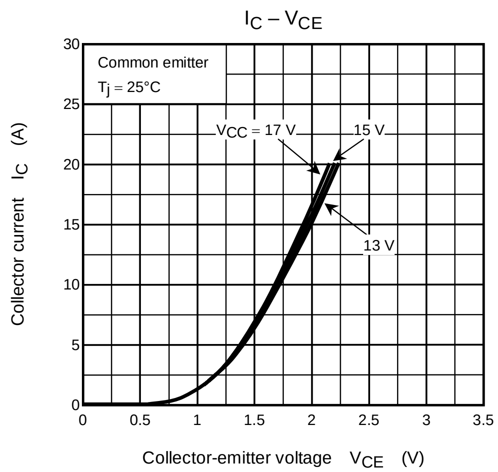
Weight: 18 g (typ.)

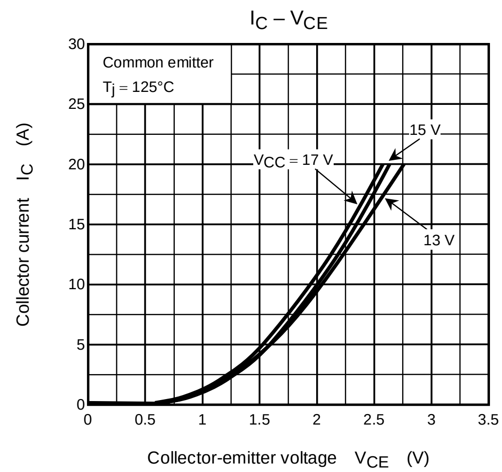
1.	PGND U	2.	U	3.	V_{BB} U	4.	PGND V	5.	V	6.	V_{BB} V
7.	PGND W	8.	W	9.	V_{BB} W	10.	C W	11.	BS W	12.	SGND W
13.	IN Z	14.	IN W	15.	FO W	16.	V_{CC} W	17.	C W	18.	BS V
19.	SGND V	20.	IN Y	21.	IN V	22.	FO V	23.	V_{CC} V	24.	C U
25.	BS U	26.	SGND U	27.	IN X	28.	IN U	29.	FO U	30.	V_{CC} U

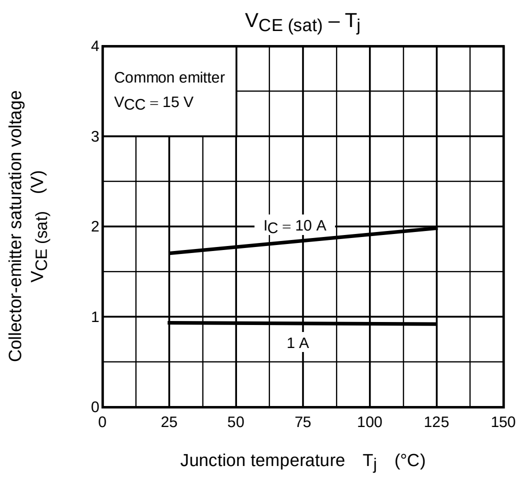
Truth Table

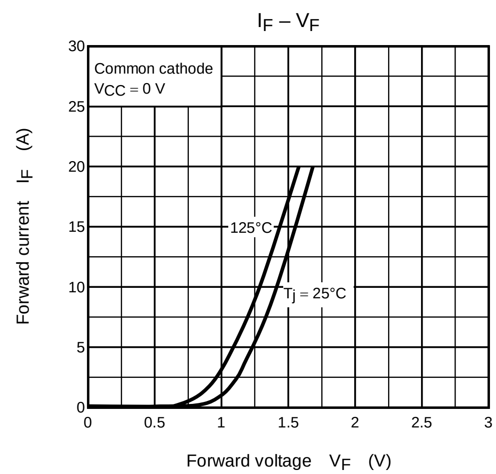
Protection Circuit Detection State			Input		IGBT State		Fault Output
High Side Under Voltage	Low Side Under Voltage	Short Circuit	IN (X) High Side Arm	IN (X) Low Side Arm	High Side Arm	Low Side Arm	FO (X)
Un-Detecting	Un-Detecting	Un-Detecting	H	H	OFF	OFF	OFF
Un-Detecting	Un-Detecting	Un-Detecting	H	L	OFF	ON	OFF
Un-Detecting	Un-Detecting	Un-Detecting	L	H	ON	OFF	OFF
Un-Detecting	Un-Detecting	Un-Detecting	L	L	OFF	OFF	OFF
Detecting	Un-Detecting	Un-Detecting	H	H	OFF	OFF	OFF
Detecting	Un-Detecting	Un-Detecting	H	L	OFF	ON	OFF
Detecting	Un-Detecting	Un-Detecting	L	H	OFF	OFF	OFF
Detecting	Un-Detecting	Un-Detecting	L	L	OFF	OFF	OFF
Un-Detecting	Detecting	Un-Detecting	H	H	OFF	OFF	OFF
Un-Detecting	Detecting	Un-Detecting	H	L	OFF	OFF	OFF
Un-Detecting	Detecting	Un-Detecting	L	H	OFF	OFF	OFF
Un-Detecting	Detecting	Un-Detecting	L	L	OFF	OFF	OFF
Detecting	Detecting	Un-Detecting	H	H	OFF	OFF	OFF
Detecting	Detecting	Un-Detecting	H	L	OFF	OFF	OFF
Detecting	Detecting	Un-Detecting	L	H	OFF	OFF	OFF
Detecting	Detecting	Un-Detecting	L	L	OFF	OFF	OFF
Un-Detecting	Un-Detecting	Detecting	H	H	OFF	OFF	ON
Un-Detecting	Un-Detecting	Detecting	H	L	OFF	OFF	ON
Un-Detecting	Un-Detecting	Detecting	L	H	OFF	OFF	ON
Un-Detecting	Un-Detecting	Detecting	L	L	OFF	OFF	ON

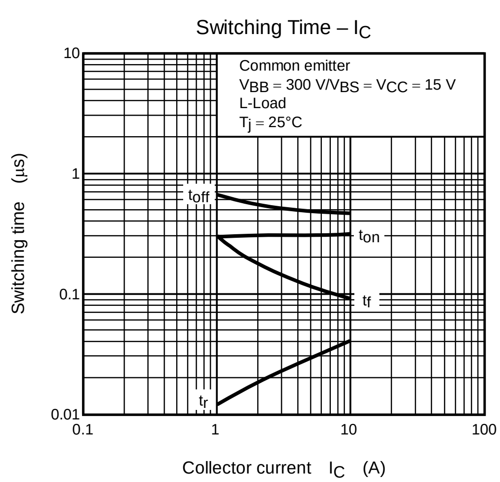
- The above has indicated a part for single arm.
- There is no relevance of operation between arms.
- When the input of a high side arm and a low side arm is simultaneously set to “L”, IGBT of a high side arm and a low side arm turns off.
- FO (X) terminal is turned on in the meantime at the same time, as for the output of Phase which detected the load short circuit state, it will maintain the OFF between 2 ms, if a Short Current Protection detects a Short Current state for a lower arm IGBT. Although an incoming signal is reset by an upper arm and a lower arm being simultaneously set to “H” in the back in this state, OFF of an output and FO (X) are maintained between 2 ms. Although FO (X) is turned off when FO (X) terminal for 2 ms will not be in the simultaneous “H” state of an upper arm and a lower arm in during ON time, an output maintains OFF. This release is made by an upper arm and a lower arm being simultaneously set to “H”.
  (Short current protection is a non-repetition. When FO (X) turns on, please turn off the input of all phase.)
- Over Temperature Protection circuit is not built in.

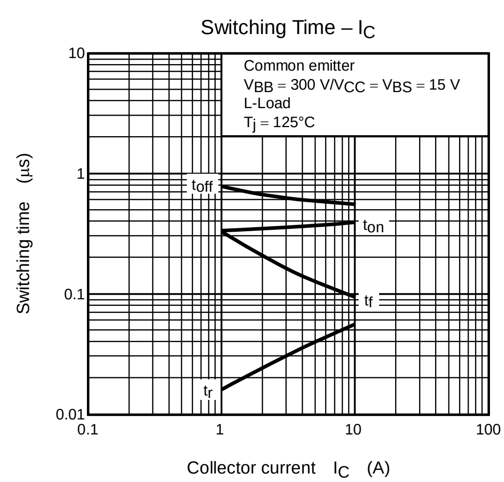

$I_C – V_{CE}$
Common emitter
T_j = 25°C
V_{CC} = 17 V
15 V
13 V
Collector current I_C (A)
Collector-emitter voltage V_{CE} (V)

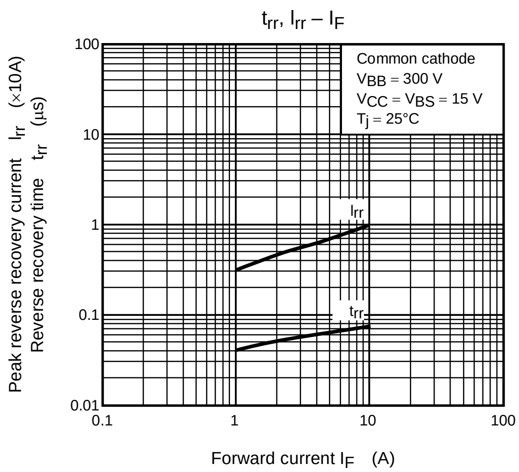

$I_C – V_{CE}$
Common emitter
T_j = 125°C
15 V
V_{CC} = 17 V
13 V
Collector current I_C (A)
Collector-emitter voltage V_{CE} (V)


$V_{CE (sat)} – T_j$
Common emitter
V_{CC} = 15 V
I_C = 10 A
1 A
Collector-emitter saturation voltage $V_{CE (sat)}$ (V)
Junction temperature T_j (°C)

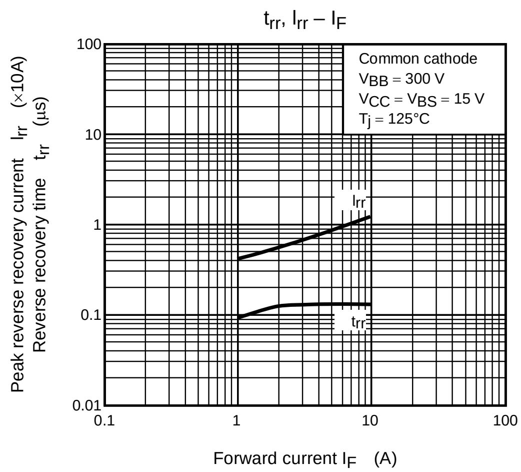

$I_F – V_F$
Common cathode
V_{CC} = 0 V
125°C
T_j = 25°C
Forward current I_F (A)
Forward voltage V_F (V)


Switching Time – I_C
Common emitter
V_{BB} = 300 V/V_{BS} = V_{CC} = 15 V
L-Load
T_j = 25°C
t_{off}
t_{on}
t_f
t_r
Switching time (µs)
Collector current I_C (A)

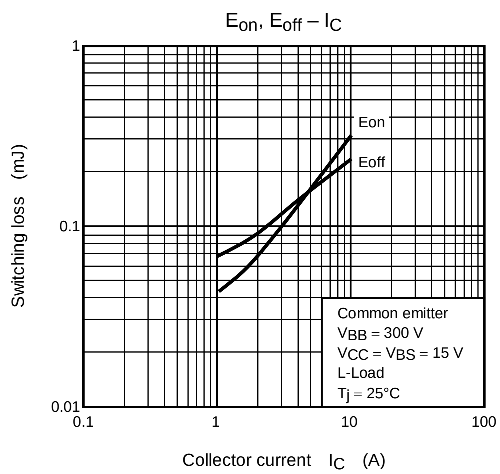

Switching Time – I_C
Common emitter
V_{BB} = 300 V/V_{CC} = V_{BS} = 15 V
L-Load
T_j = 125°C
t_{off}
t_{on}
t_f
t_r
Switching time (µs)
Collector current I_C (A)



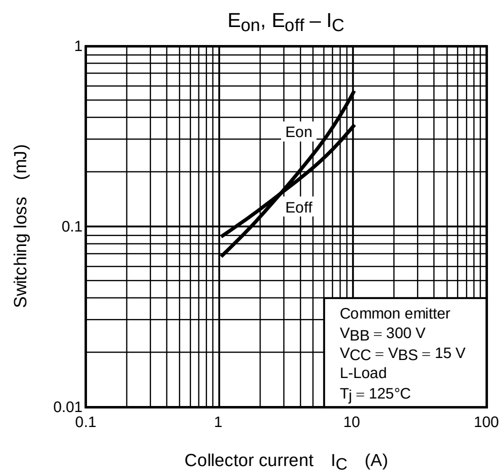
trr, Irr – IF
Common cathode
VBB = 300 V
VCC = VBS = 15 V
Tj = 25°C
Irr
trr
Peak reverse recovery current Irr (×10A)
Reverse recovery time trr (μs)
Forward current IF (A)



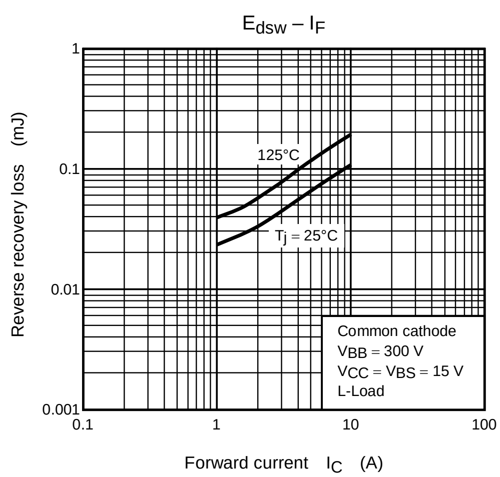
trr, Irr – IF
Common cathode
VBB = 300 V
VCC = VBS = 15 V
Tj = 125°C
Irr
trr
Peak reverse recovery current Irr (×10A)
Reverse recovery time trr (μs)
Forward current IF (A)



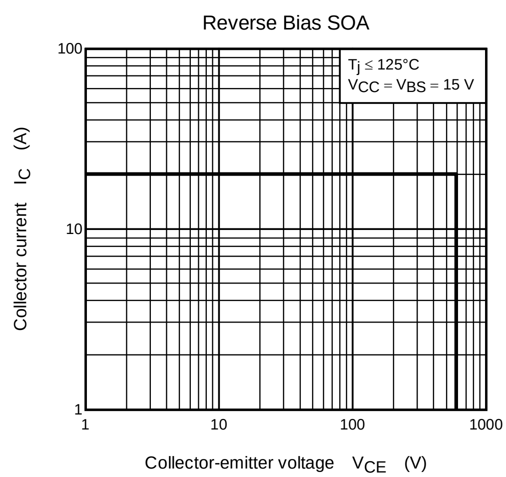
Eon, Eoff – IC
Eon
Eoff
Common emitter
VBB = 300 V
VCC = VBS = 15 V
L-Load
Tj = 25°C
Switching loss (mJ)
Collector current IC (A)



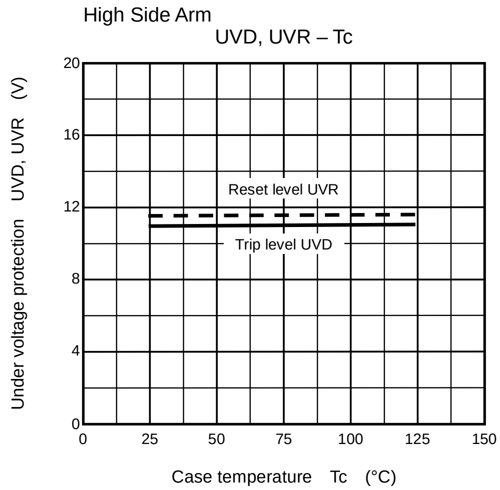
Eon, Eoff – IC
Eon
Eoff
Common emitter
VBB = 300 V
VCC = VBS = 15 V
L-Load
Tj = 125°C
Switching loss (mJ)
Collector current IC (A)

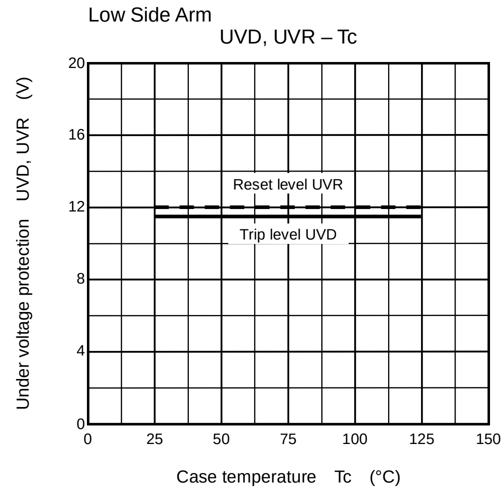


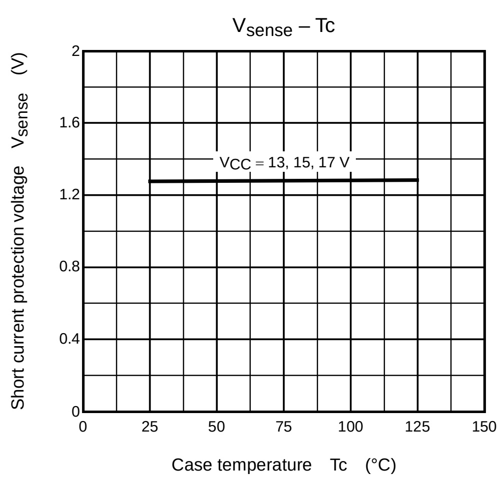
Edsw – IF
125°C
Tj = 25°C
Common cathode
VBB = 300 V
VCC = VBS = 15 V
L-Load
Reverse recovery loss (mJ)
Forward current IC (A)

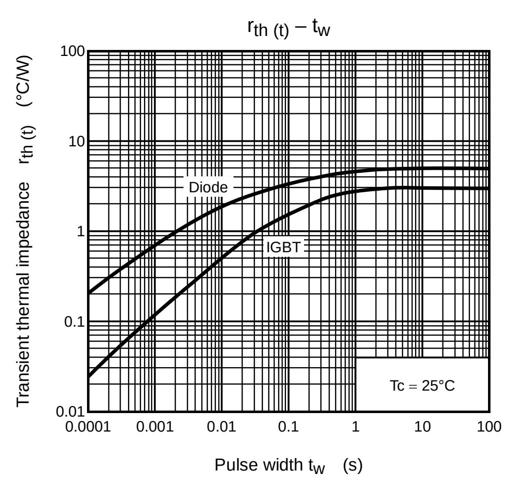


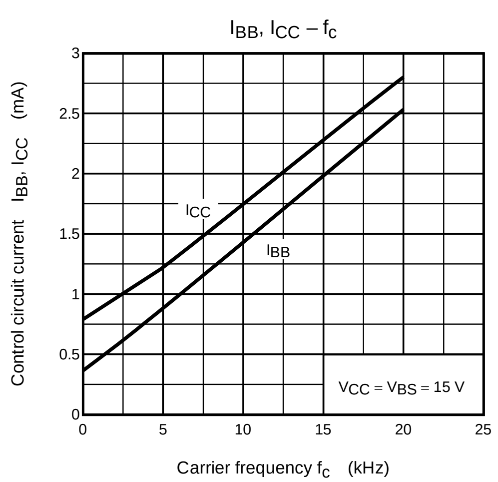
Reverse Bias SOA
Tj ≤ 125°C
VCC = VBS = 15 V
Collector current IC (A)
Collector-emitter voltage VCE (V)

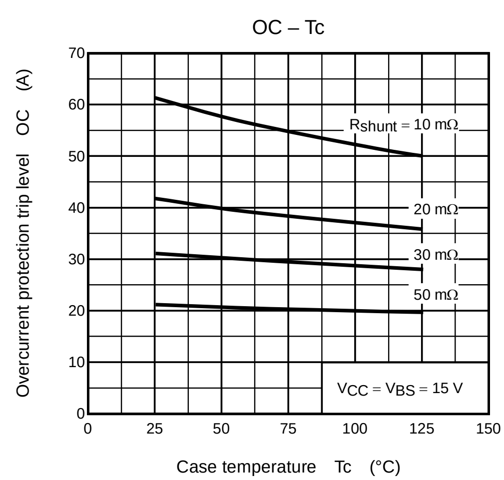

High Side Arm
UVD, UVR – Tc
Under voltage protection UVD, UVR (V)
Reset level UVR
Trip level UVD
Case temperature Tc (°C)


Low Side Arm
UVD, UVR – Tc
Under voltage protection UVD, UVR (V)
Reset level UVR
Trip level UVD
Case temperature Tc (°C)


Vsense – Tc
Short current protection voltage Vsense (V)
VCC = 13, 15, 17 V
Case temperature Tc (°C)


rth (t) – tw
Transient thermal impedance rth (t) (°C/W)
Diode
IGBT
Tc = 25°C
Pulse width tw (s)


IBB, ICC – fc
Control circuit current IBB, ICC (mA)
ICC
IBB
VCC = VBS = 15 V
Carrier frequency fc (kHz)


OC – Tc
Overcurrent protection trip level OC (A)
Rshunt = 10 mΩ
20 mΩ
30 mΩ
50 mΩ
VCC = VBS = 15 V
Case temperature Tc (°C)

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  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the “Handling Guide for Semiconductor Devices,” or “TOSHIBA Semiconductor Reliability Handbook” etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury (“Unintended Usage”). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer’s own risk.
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